Linux Powered Autonomous Arctic Buoys

Satish Chetty

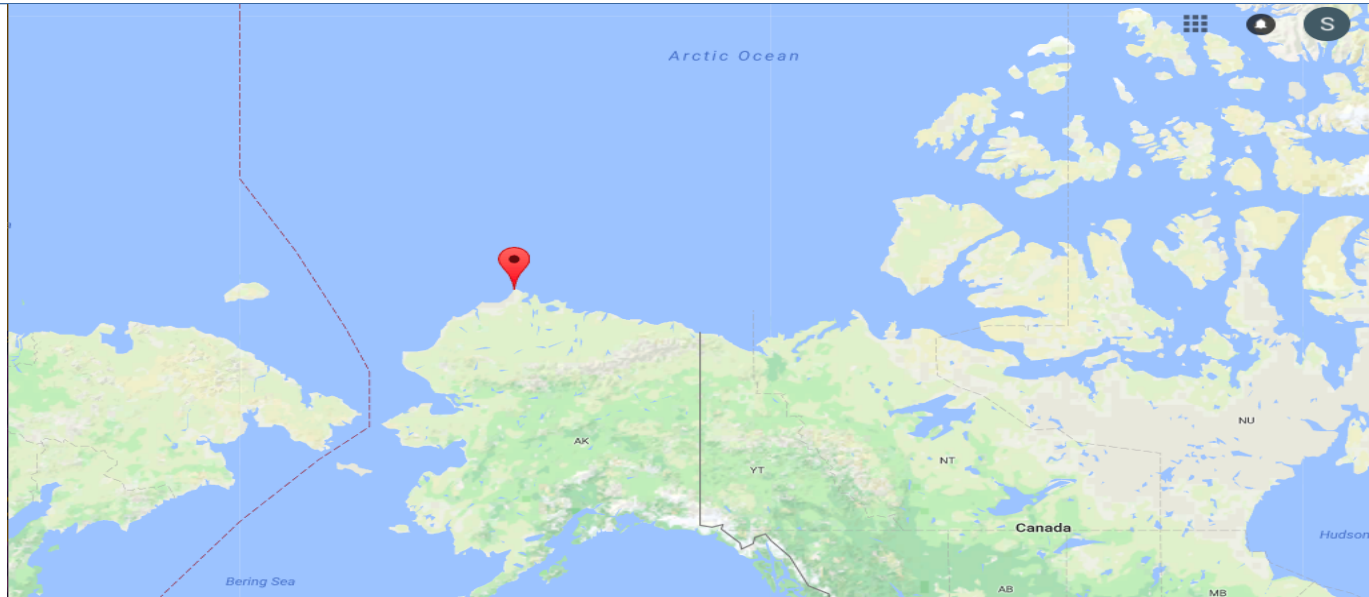Embedded Linux Conference – Prague

October 23rd, 2017

Introduction

- Space Systems

- Embedded Systems

- My Polar work

- Special Instrumentation

- Commercial and Industrial Products

The Arctic Buoy - Location

- Near Barrow (Utqiaġvik), Alaska, USA -40°C/F
- 1,300 miles (2,100 km) from the North Pole (71°N)
- Northern most US town. No roads to this town
- Cold, Dry and no wind barriers
- 65 days of darkness
- On the Arctic Ocean Coast
- Polar bears, Arctic foxes and other wildlife
- Good research infrastructure

Challenges

- Size
- Weight
- Power
- Performance
- Cost (SWAPP-C)
- Communication (Local and remote)
- Data storage
- Transport to site

- Assembly
- Operation (Autonomous, Semi Autonomous, Manual)
- Disassembly
- Removal from Site
- Transport back to lab or disposal
- Weather and Environment
- Other Challenges (Animals)

The Deployment

The Computer

- Fanless -40°C to +85°C with CPU clocked at 454MHz
- Configurable to operate at lower CPU speed
- Software based peripheral on/off
- Can be scaled back to use only ½ watt
- Varying Operating Voltage
- Built in sleep timers (clock drifts)
- Custom (Debian) Kernel
- *uvcvideo*, wifi, support for USB modems
- Removing non essential packages
- Reduce boot and shutdown time
- Testing, testing and lots of testing

The Sensor Package

- Sonar for Ice thickness
- Solar Sensor for incoming sunlight
- Solar Sensor for reflected sunlight
- UV Sensors*
- External Weather Station interface via SDR
- Multiple 4m long temperature cables (multiple sensors)
- Wifi
- Cell Modem
- Satellite Modem*
- 4 HD Cameras
- Industrial SD Card for local storage and remote server for uploads

The Basic Operation

- Start up and check disk for issues
- Start Weather data logger
- Start 1 wire temperature logger
- Log Sensor values
- Start camera operation with auto focus
- Log system parameters (battery, disk space, CPU temp, IP address)
- (Try to) send system log, sensor data and images
- Move to archive
- Initiate System shutdown.
- Disk flush
- Sleep for 'X' seconds

The Computer

Challenges

- Arctic Foxes

Challenges - Pictures

- Polar Bears

Challenges - Pictures

- Rime

Challenges - Pictures

Linux Powered Autonomous Arctic Buoys - Embedded Linux Conference - Prague October 2017

Challenges - Pictures

Deployment Constraints

- Manual Deployment and Removal

- Shipping via air

- Solar with battery backup

- Local Storage (SD card)

- BT, Wifi for local

- Vibration

- Sensor and Cabling failure

- Cellular modem and Satellite modem (Iridium)

- Measure & Store Solar Radiation, Ice & Air Temperature, Weather, HD Images

- Transmit via cellular network

Size, Weight Power & Cost

- Buoy Structure

- Batteries

- Cameras

- Solar Panels

- Sensors and Instruments

- COTS and very few custom parts

- Water proof box and ring buoy

- Shipping and Logistic Challenges

- Assembly and Disassembly Issues

Power

- Lithium Batteries

- Charge Controllers

- Vertical Solar panels

- Sleep Timers

- Cameras and Transmitters are power intensive operations

Questions

Linux Powered Autonomous Arctic Buoys - Embedded Linux Conference - Prague October 2017